PHYTOTOXICOLOGY SURVEY REPORT

NORTON - NIAGARA FALLS (1990 & 1991)

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NORTON - NIAGARA FALLS (1990 & 1991)

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Abstract

This document is composed of two reports bound under one cover. It describes the results of Phytotoxicology surveys around Norton in Niagara Falls for the two consecutive years 1990 and 1991. No air pollution injury symptoms were observed on vegetation in the vicinity of the company. Tree foliage close to Norton had marginally elevated concentrations of titanium, copper, molybdenum, chromium, aluminum, and vanadium. However, ULN guidelines were not exceeded, the area affected was small, and there is no environmental consequence to plants and soil.

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Executive Summary

The Phytotoxicology Section first conducted terrestrial environmental sampling in the vicinity of Norton in Niagara Falls on September 12, 1990. Surface soil (0-5 cm and 5-10 cm) was collected from 6 sites and tree foliage was collected from 10 sites. The samples were analyzed for total titanium, sulphur, copper, nickel, zinc, lead, cadmium, iron, sodium, cobalt, molybdenum, manganese, chromium, aluminum, strontium, and vanadium. In addition, the soil samples were analyzed for pH and electrical conductivity. The survey was repeated on September 23 1991. One additional site was added to the vegetation survey in 1991. Soil was not collected in the second year.

Air pollution injury symptoms were not observed on survey vegetation, or vegetation elsewhere in the general survey area. Soil and vegetation ULN guidelines were not exceeded for any of the elements. However, marginally elevated concentrations of titanium, copper, molybdenum, chromium, aluminum, and vanadium were detected in vegetation close to and downwind of Norton. Soil concentrations were not elevated. The impact area was small, and the marginal contamination had no environmental consequence to plants and soil. Although the contamination was minimal, periodic monitoring may be warranted.

Phytotoxicology Assessment Investigation in the Vicinity of Norton, Niagara Falls - 1990

Introduction

At the request of the Ministry's Welland District Office, the Phytotoxicology Section initiated a surveillance investigation of vegetation and soil in the vicinity of the Norton company in Niagara Falls. Norton is a large facility that is primarily involved in the production of aluminum oxide for use as an abrasive.

The purpose of the Phytotoxicology survey was twofold - examine nearby foliage for air pollution injury symptoms and; sample vegetation and soils for chemical analysis to determine the impact of emissions from Norton.

Phytotoxicology Surveillance Activities

On 12 and 13 September 1990, Mr. George Vasiloff of the Phytotoxicology Section visited the area and established a network of 10 vegetation and 6 soil surveillance sites. Wherever possible, site locations were selected to provide representation on all sides of the large factory complex. Since the prevailing summer winds in the area are predominately from the south and southwest, the three sites (2, 4 and 5) located northeast of the plant are considered to be downwind locations. The survey sites are shown in the attached figure.

At each site, silver maple was available for observational and sampling purposes. Foliage on tree crowns facing the Norton plant was examined for visual evidence of air pollution injury and surface particulates. A summary of the observational notes is provided in Table 1. The table shows that no foliar injury attributable to air pollutants was observed. However, traces of an unidentified particulate material were observed on foliage at sites 4 and 8. Following the observational aspect of the survey, triplicate samples of the examined silver maple foliage were collected for chemical analysis.

At 6 of the survey sites selected for maple foliage sampling, an exposed and undisturbed area was selected for the collection of soil for chemical analysis. Triplicate samples of 0-5 cm and 5-10 cm soil were obtained using a clean standard soil core borer (Oakfield Sampler). Sampling at each of these 6 sites was done in a random manner following an imaginary "X" pattern. Each of the triplicate samples contained no fewer than 25 individual soil cores. During the collection of vegetation and soil, new vinyl gloves were worn by the investigator at each site in order to avoid sample contamination.

Vegetation and soil samples were returned to the Phytotoxicology laboratory in Toronto and submitted for processing. Vegetation samples were processed as not-washed and oven-dried according to a standard procedure. Similarly, soil samples were processed in conformity to a standard procedure developed for this medium. Processed vegetation and soil samples were then submitted to the Ministry's Inorganic Trace Contaminants laboratory for the analysis of total copper, nickel, iron, zinc, lead, cadmium, sodium, cobalt, molybdenum, manganese, chromium, aluminum, strontium, vanadium, titanium and sulphur. Electrical conductivity and pH tests for the soils were also requested.

Chemical Analysis Results - Silver Maple Foliage

Concentrations of 16 elements detected in silver maple foliage collected at 10 survey sites in the vicinity of Norton are summarized in Table 2. Shown at the base of the table are Phytotoxicology Upper Limit of Normal Guidelines for most elements. The rationale behind the derivation of the guidelines is provided in the attached appendix.

Concentrations of titanium and aluminum were elevated at the two sites closest to the plant (3 and 8) and at the closest downwind site (2). Although elevated, most of these concentrations did not exceed the existing ULN guidelines. There are currently no ULN's for titanium and aluminum, the two elements that were most elevated relative to the control samples and other sites in the survey area. For example, the aluminum concentration in maple foliage at Site 8, 150 m SW of Norton, was almost five times higher than the control sample, and the foliar aluminum concentration at Site 2, 300 m NE of the source, was 3 times higher than the control. Similarly, titanium foliar concentrations at Sites 2 and 8 were 7 and 5 times higher (respectively) than the control site.

The fact that concentrations of titanium and aluminum, and to a lesser degree sodium and zinc were highest at the sample sites closest to and/or most directly downwind of Norton, suggests that the company is an emission source of these elements.

The ULN guideline for manganese was exceeded at Sites 2 and 9 and the control site (10). As evident from these data, manganese can be quite variable in tree foliage, although the magnitude of variation detected at these three sites is rather unusual. The data are too variable to determine with confidence if Norton is a source of manganese.

Soil - 0-5 cm Depth

Triplicate samples of 0-5 cm soil were collected at five sites near the Norton plant and at a control location. Concentrations of 16 elements found in the soils have been summarized in Table 3. Of the 16 elements examined, the concentration of only one element was found to be in excess of the ULN guidelines. At survey Site 8, the mean molybdenum concentration (4 ppm) was slightly higher than the 3 ppm guideline.

Even though values of the other elements were below existing ULN guidelines, a

marginal concentration gradient (higher concentration at sites closest to and/or downwind of Norton) was apparent for titanium, copper, zinc, lead, sodium, molybdenum, manganese and vanadium. However, the limited nature of the sampling program precludes the determination of any causal role/relationship with emissions from the Norton plant.

Soil - 5-10 cm Depth

Mean concentrations of 16 elements detected in the deeper 5-10 cm soils at sites near the Norton plant are summarized in Table 4. No ULN guidelines have been established for elemental concentrations at this depth. However, when compared to the 0-5 cm guidelines, only molybdenum (4 ppm) in the 5-10 cm soil at Site 8 was excessive. Although the other elements were below 0-5 cm guidelines, once again values of several were consistently higher at Sites 2, 3 or 8. The concentrations in the 5-10 cm soil samples were very similar to the 0-5 cm samples.

Electrical Conductivity and pH of Soil

Electrical conductivity and pH tests were conducted on 0-5 cm soils collected at 6 sites in the vicinity of the Norton plant. Electrical conductivity (EC) measures the concentration of soluble salts in the soil. The higher the soluble salt concentration, the higher the EC. Elevated concentrations of soluble salts can adversely affect or kill established plants by interfering with the mechanism of water uptake from the soil. Tests for pH indicate the acidity or alkalinity of soils. The pH scale is from 0 to 14. Values below 7 are considered acidic while those above are alkaline.

Electrical conductivity and pH test results are summarized in Table 5. Results indicate that the EC at all survey sites was relatively low and suitable for most plants. With respect to pH, all of the values found at the survey sites were within a range considered to be acceptable.

Summary

A survey was conducted at selected sites in the vicinity of the Norton plant to assess the effects of emissions on vegetation and soil. No air pollution injury was observed on vegetation at any of the survey sites although traces of particulate material were noted on foliage at Sites 4 and 8. Chemical analysis of silver maple foliage indicated that concentrations of some elements (primarily titanium and aluminum) were elevated at sites close to and downwind of the plant.

Analysis of 0-5 cm and 5-10 cm soils disclosed that concentrations of molybdenum were above the 0-5 cm ULN guideline at Site 8. Concentrations of several of the other elements were found to be slightly elevated at sites located either close to or downwind of the plant. Soil pH at all sites was within an acceptable range.

This initial survey suggests that Norton is a relatively minor source of titanium and aluminum and possibly a few additional elements. Because many of these elements are heavy metals, they have the potential to accumulate in surface soil.

This survey was not intended as an exhaustive investigation of Norton; rather, it was intended only as a preliminary survey to determine if ongoing or historical contamination was present. In view of the marginal elevations in vegetation and soil, a review of the company's emissions is recommended. Similarly, it is recommended that this survey be repeated in a few years (3-5) to determine if heavy metals have continued to accumulate in the soil.

TABLE: 1 Observational Notes of Surveillance Foliage Examined in the Vicinity of Norton, Niagara Falls - 1990

Survey Site Number	Distance & Direction from Norton	Vegetation Examined	Observations
1	0.4 km SW	Silver maple	Powdery mildew evident on scattered foliage.
		Manitoba maple	No air pollution injury.
		Linden	" " " "
		White pine	" " " "
		Wild grape	" " " "
2	0.3 km NE	Silver maple	No air pollution injury.
		Manitoba maple	" " " "
		Weeping willow	" " " "
		Cedars	" " " "
3	0.15 km SE	Silver maple	Trace terminal necrosis on scattered foliage.
		Raspberry	No air pollution injury.
		Tomatoes	" " " "
		Pole beans	" " " "
4	0.45 km NE	Silver maple	No air pollution injury.
		Lilac	Unknown particulate material observed on leaf tips.
5	0.7 km NE	Silver maple	No air pollution injury.
6	0.3 km SE	Silver maple	No air pollution injury.
		Manitoba maple	" " " "
7	0.65 km SE	Silver maple	No air pollution injury.
		Green ash	" " " "
8	0.15 km SW	Silver maple	No air pollution injury.
		Manitoba maple	" " " "
		Ash	" " " "
		Red oak	Unknown particulate material on foliar tips.
		Dogwood	No air pollution injury.
		Wild grape	Unknown particulate material on foliar tips.
9	0.6 km NW	Silver maple	No air pollution injury.
		Ash	" " " "
10	5.0 km S (Control site)	Silver maple	No air pollution injury.
		Manitoba maple	" " " "
		Ash	" " " "

TABLE: 2 Concentrations* of 16 Inorganic Elements Detected in Silver Maple Foliage Collected in the Vicinity of Norton, Niagara Falls - 1990

Survey Site Number	Vegetation Sampled	Distance & Direction from Norton	Elements						
			Ti	S (%)	Cu	Ni	Zn	Pb	Cd
1	Silver maple	0.4 km SW	18	0.3	8	2T	54	2T	DL
2	Silver maple	0.3 km NE	82	0.2	12	2T	103	3T	0.2T
3	Silver maple	0.15 km SE	38	0.2	6	1T	47	2T	DL
4	Silver maple	0.45 km NE	22	0.2	4	2T	27	1T	0.1T
5	Silver maple	0.7 km NE	15	0.2	7	2T	41	1T	0.2T
6	Silver maple	0.3 km SW	17	0.2	5	2T	56	2T	0.2T
7	Silver maple	0.65 km SE	9	0.2	5	1T	33	1T	0.1T
8	Silver maple	0.15 km SW	60	0.2	14	2T	48	3T	0.1T
9	Silver maple	0.6 km NW	18	0.2	6	2T	71	2T	0.2T
10	Silver maple (Control Site)	5.0 km S	12	0.2	12	2T	44	1T	0.2T
Phytotoxicology Upper Limit of Normal (ULN) Guidelines for urban foliage.			NG	0.4%	20	7	250	60	2

*ug/g, dry weight, mean of triplicate samples and analysis.
Sulphur values given as percent (%) - dry weight
T - a trace measurable amount, interpret with caution.
DL - at or below analytical detection limit.
NG - ULN guideline not established.

Ti - titanium
S - sulphur
Cu - copper
Ni - nickel
Zn - zinc
Pb - lead
Cd - cadmium

cont'd...

TABLE: 2 Cont'd

Survey Site Number	Vegetation Sampled	Distance & Direction from Norton	Elements* Na	Co	Mo	Mn	Cr	Al	Sr	V
1	Silver maple	0.4 km SW	17	0.2T	0.6T	53	0.5T	81	28	1T
2	Silver maple	0.3 km NE	38	0.2T	0.8T	220	0.8T	293	45	3T
3	Silver maple	0.15 km SE	22	DL	0.3T	93	DL	203	34	1T
4	Silver maple	0.45 km NE	33	DL	0.3T	47	0.5T	122	30	1T
5	Silver maple	0.7 km NE	20	DL	0.4T	21	0.5T	82	23	1T
6	Silver maple	0.3 km SW	41	0.4T	1.4T	40	DL	81	49	1T
7	Silver maple	0.65 km SE	19	DL	DL	45	DL	63	27	1T
8	Silver maple	0.15 km SW	62	0.3T	0.6T	36	2.0T	463	20	3T
9	Silver maple	0.6 km NW	28	0.3T	DL	160	DL	73	30	1T
10	Silver maple (Control Site)	5.0 km S	22	DL	0.4T	180	DL	96	63	1T
Phytotoxicology Upper Limit of Normal (ULN) Guidelines for urban foliage.			350	2	1.5	100	8	500	NG	5

*ug/g, dry weight, mean of triplicate samples and analysis.
T - a trace measurable amount, interpret with caution.
DL - at or below analytical detection limit.
NG - ULN guideline not established.
Underlined values exceed ULN guidelines.

Na - sodium
Co - cobalt
Mo - molybdenum
Mn - manganese
Cr - chromium
Al - aluminum
Sr - strontium
V - vanadium

TABLE: 3 Concentrations* of 16 Inorganic Elements Detected in 0-5 cm Soil Collected in the Vicinity of Norton, Niagara Falls - 1990

Survey Site Number	Distance & Direction from Norton	Elements							
		Ti	S (%)	Cu	Ni	Zn	Pb	Cd	Fe (%)
1	0.4 km SW	0.5	0.05	36	23	133	42	0.5T	2.3
2	0.3 km NE	0.8	0.17	44	29	210	83	1.0	1.9
3	0.15 km SE	0.5	0.07	32	20	140	72	0.6	1.6
5	0.7 km NE	0.3	0.03	11	11	52	12	0.2T	1.2
8	0.15 km SW	1.0	0.04	64	31	240	101	0.4T	2.6
10 (Control) (Site)	5.0 km S	0.6	0.07	27	36	120	58	0.4	1.8
Phytotoxicology Upper Limit of Normal (ULN) Guidelines for 0-5 cm urban soil.		NG	NG	100	60	500	500	4	3.5

*ug/g, dry weight, mean of triplicate samples and analysis.
Sulphur and iron - percent (%) - dry weight.
T - a trace measurable amount, interpret with caution.
NG - ULN guideline not established.

Ti - titanium
S - sulphur
Cu - copper
Ni - nickel
Zn - zinc
Pb - lead
Cd - cadmium
Fe - iron

cont'd....

TABLE: 3 (Cont'd)

Survey Site Number	Distance & Direction from Norton	Elements* Na	Co	Mo	Mn	Cr	Al (%)	Sr	V
1	0.4 km SW	100	10	1.2T	583	28	1.7	36	40
2	0.3 km NE	72	10	2.1	480	29	1.7	20	64
3	0.15 km SE	180	6	1.1T	363	24	1.4	24	35
5	0.7 km NE	130	5	0.4T	340	13	0.8	36	24
8	0.15 km SW	160	9	3.9	493	39	1.5	27	58
10 (Control) (Site)	5.0 km S	74	9	0.5T	200	27	2.3	31	38
Phytotoxicology Upper Limit of Normal (ULN) Guidelines for 0-5 cm urban soil.		NG	25	3	700	50	NG	NG	70

*ug/g, dry weight, mean of triplicate samples and analysis.
Aluminum - percent, dry weight.
T - a trace measurable amount, interpret with caution.
NG - ULN guideline not established.
Underlined values exceed ULN guidelines.
NE - ULN guidelines not established.

Na - sodium
Co - cobalt
Mo - molybdenum
Mn - manganese
Cr - chromium
Al - aluminum
Sr - strontium
V - vanadium

TABLE: 4 Concentrations* of 16 Inorganic Elements Detected in 5-10 cm Soil Collected in the Vicinity of Norton, Niagara Falls - 1990

Survey Site Number	Distance & Direction from Norton	Elements*							
		Ti	S (%)	Cu	Ni	Zn	Pb	Cd	Fe (%)
1	0.4 km SW	0.5	0.04	40	24	130	42	0.6	2.4
2	0.3 km NE	0.8	0.15	45	31	210	84	0.9	1.9
3	0.15 km SE	0.5	0.07	34	21	137	78	0.6	1.7
5	0.7 km NE	0.3	0.03	11	11	45	<10	DL	1.2
8	0.15 km SW	1.0	0.07	66	33	257	107	0.6	2.6
10 (Control) (Site)	5.0 km S	0.6	0.05	26	38	120	68	0.6	1.9

*ug/g, dry weight, mean of triplicate samples and analysis.
Sulphur and iron - percent, dry weight.
DL - at or below analytical detection limit.

Ti - titanium
S - sulphur
Cu - copper
Ni - nickel
Zn - zinc
Pb - lead
Cd - cadmium
Fe - iron

cont'd....

TABLE: 4 (Cont'd)

Survey Site Number	Distance & Direction from Norton	Elements*							
		Na	Co	Mo	Mn	Cr	Al (%)	Sr	V
1	0.4 km SW	109	10	0.8T	577	29	1.7	41	40
2	0.3 km NE	87	10	2	373	30	1.9	21	66
3	0.15 km SE	267	7	2	353	24	1.4	23	37
5	0.7 km NE	160	5	DL	340	13	0.8	42	26
8	0.15 km SW	147	9	4	503	40	1.5	31	60
10 (Control) (Site)	5.0 km S	82	10	1.6T	197	29	2.3	30	39

*ug/g, dry weight, mean of triplicate samples and analysis.
Aluminum - percent, dry weight.
T - a trace measurable amount, interpret with caution.
DL - at or below analytical detection limit.

Na - sodium
Co - cobalt
Mo - molybdenum
Mn - manganese
Cr - chromium
Al - aluminum
Sr - strontium
V - vanadium

TABLE: 5 pH and Electrical Conductivity of 0-5 cm Soils
Collected at Survey Sites in the Vicinity of Norton, Niagara Falls

Sample Site Number	pH	Electrical Conductivity
1	7.13	0.20
2	6.48	0.16
3	6.76	0.28
5	6.81	0.18
8	7.29	0.22
10 (Control)	6.14	0.24

Electrical Conductivity values given in millisiemens/cm

Data are average of triplicate results

Interpretation of Electrical Conductivity Values

Conductivity Reading	Rating	Plant Response
0 - 0.25	L	Suitable for most plants.
0.26 - 0.45	M	Suitable for most plants.
0.46 - 0.70	H	May reduce emergence and cause slight to severe damage to salt sensitive plants.
0.71 - 1.00	E	May prevent emergence and cause slight to severe damage to most plants.
1.00	E	Expected to cause severe damage to most plants.

Appendix

Derivation and Significance of the MOEE Phytotoxicology "Upper Limits of Normal" Contaminant Guidelines.

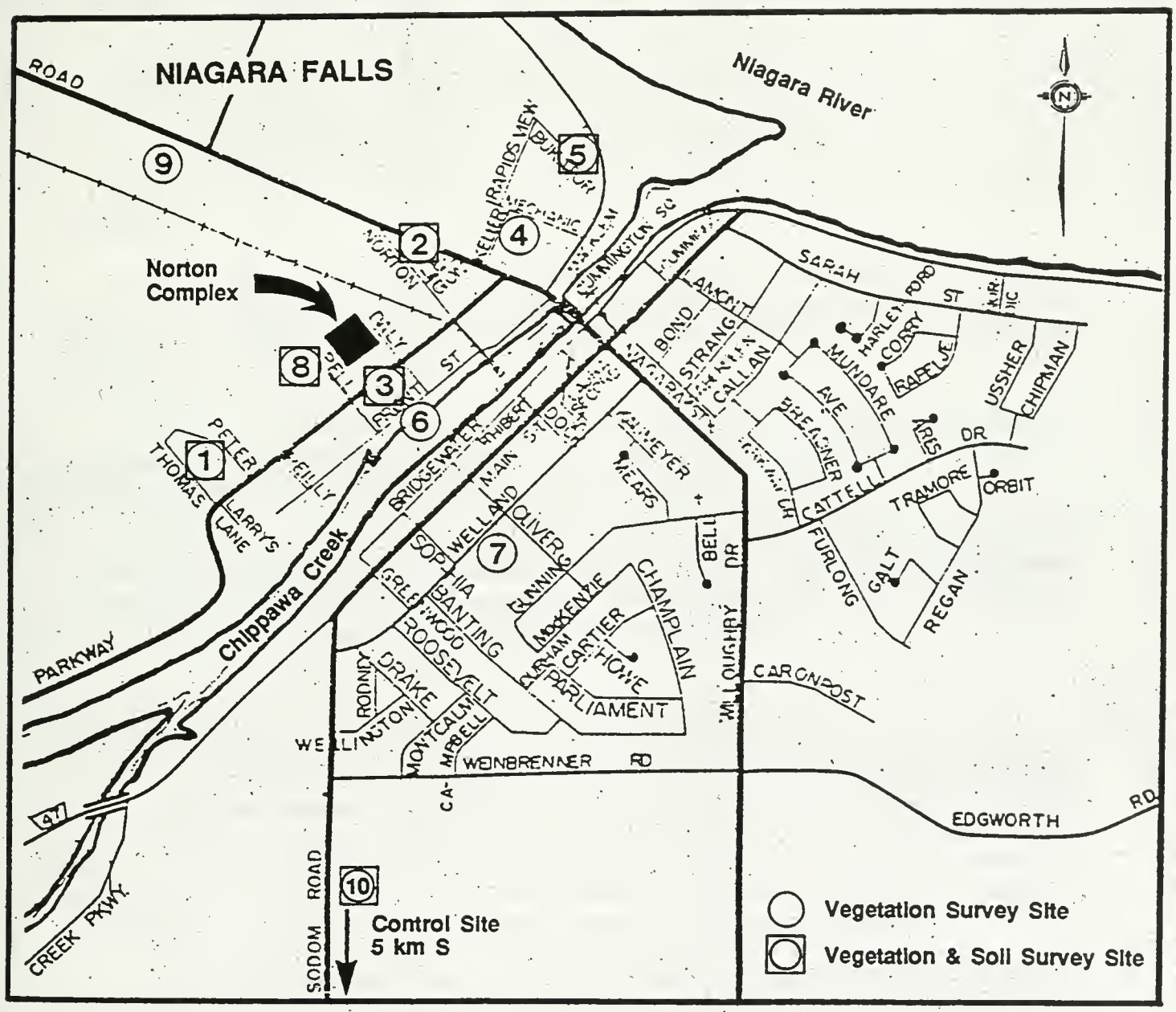
The MOEE Upper Limits of Normal (ULN) contaminant guidelines represent the expected maximum concentration in surface soil, foliage (trees and shrubs), grass, moss bags, and snow from areas in Ontario not exposed to the influence of a pollution source. Urban ULN guidelines are based on samples collected from urban centres, whereas rural ULN guidelines were developed from non-urbanized areas. Samples were collected by Phytotoxicology staff using standard sampling procedures (reference: *Ontario Ministry of the Environment. 1989. Ontario Ministry of the Environment "Upper Limit of Normal" Contaminant Guidelines for Phytotoxicology Samples. Phytotoxicology Section, Air Resources Branch: Technical Support Sections NE and NW Regions, Report No. ARB-138-88-Phyto. ISBN: 0-7729-5143-8.*). Chemical analyses were conducted by the MOEE Laboratory Services Branch.

The ULN is the arithmetic mean plus three standard deviations of the suitable background data for each chemical element and parameter. This represents 99% of the sample population. This means that for every 100 samples that have not been exposed to a pollution source, 99 will fall within the ULN.

The ULNs do not represent maximum desirable or allowable limits. Rather, they are an indication that concentrations that exceed the ULN may be the result of contamination from a pollution source. Concentrations that exceed the ULNs are not necessarily toxic to plants, animals, or people. Concentrations that are below the ULNs are not known to be toxic.

ULNs are not available for all elements. This is because some elements have a very large range in the natural environment and the ULN, calculated as the mean plus three standard deviations, would be unrealistically high. Also, for some elements, insufficient background data is available to confidently calculate ULNs. The MOEE Phytotoxicology ULNs are constantly being reviewed as the background environmental data base is expanded. This will result in more ULNs being established and may amend existing ULNs.

Phytotoxicology Vegetation and Soil Survey Sites
in the Vicinity of Norton, Niagara Falls - 1990



Phytotoxicology Investigation Report of a Survey in the Vicinity of Norton, Niagara Falls - 1991

Background

At the request of the Ministry's Welland District Office, the Phytotoxicology Section initiated a surveillance investigation in 1990 (Ref. 1) of vegetation and soil in the vicinity of the Norton in Niagara Falls. Norton is a large facility that is primarily involved in the production of aluminum oxide for use as an abrasive.

The purpose of the 1990 Phytotoxicology survey was twofold; examine nearby foliage for air pollution injury symptoms and, sample vegetation and soils for chemical analysis to determine if emissions from Norton had adversely affected the terrestrial environment.

Molybdenum concentrations exceeded the Phytotoxicology ULN guideline at one site close to Norton in 0-5 cm and 5-10 cm soils collected in 1990. Although concentrations of all elements in silver maple foliage were below ULN guidelines in 1990, values of aluminum and other elements were slightly elevated at sites close to and downwind from the factory.

Field Inspection

On 23 September 1991, Mr. George Vasiloff of the Phytotoxicology Section re-visited the area and conducted a vegetation surveillance at the 10 sites established in 1990, plus an additional location (Site 11). Figure 1 indicates that the site locations provide survey representation on all sides of the large factory complex. Since the prevailing summer winds are from the south and southwest, the three sites (2, 4 and 5) located northeast of the plant are considered to be downwind locations. Site 11 was added in 1991 to provide enhanced coverage south of Norton.

At each site, silver maple was utilized for observational and sampling purposes. Foliage on tree crowns facing the Norton plant was examined for visual evidence of air pollution injury and surface particulates. A summary of the observational notes is provided in Table 1. The table shows that no foliar injury attributable to air pollutants was observed. Following the observational aspect of the survey, triplicate samples of the examined silver maple foliage were collected for chemical analysis. During the vegetation collection, new vinyl gloves were worn by the investigator at each site in order to avoid sample contamination.

Vegetation samples were returned to the Phytotoxicology laboratory in Toronto and submitted for processing in accordance with a standard not-washed procedure. Processed samples were then submitted to the Ministry's Inorganic Trace Contaminants laboratory for the analysis of total titanium, sulphur, copper, nickel, zinc, lead, cadmium, sodium, cobalt, molybdenum, manganese, chromium, aluminum, strontium and vanadium.

Results/Discussion

Chemical analyses results for the 15 elements for which the silver maple foliage was analyzed at the survey sites in the vicinity of Norton in 1990 and 1991 are summarized in Tables 2-16. Phytotoxicology Upper Limit of Normal Guidelines (ULN) (for most elements) are listed in the tables. The rationale behind the derivation of the guidelines is provided in the attached appendix.

None of the concentrations detected in the 1991 survey foliage exceeded ULN guidelines. However, concentrations of titanium, copper, molybdenum, chromium, aluminum and vanadium were found to be marginally elevated at sites closest to the plant (2, 3, 6 and 8) in relation to control site values. In the 1990 foliage, concentrations of these elements were also marginally elevated at the same site locations. Since concentrations of these elements were highest at the sample sites closest to and/or directly downwind of Norton in two consecutive years, it is concluded that the company is likely contributing to these modest elevations. However, concentrations of these six elements are only marginally elevated above the local background and are still within the range of urban vegetation. Environmentally, these concentrations are of no consequence other than as a possible source-monitoring mechanism.

The relationship between the elevated concentrations found in foliage and proximity to the Norton is demonstrated in Figures 2-4. Contour maps showing titanium, copper and aluminum concentrations in maple foliage were computer-created using Surfer™, version 4.0 software. The maps are statistical approximations of the spatial distribution of the elements portrayed. The maps are intended only to provide information as to the approximate areas and/or patterns of distribution. Maps showing the distribution of molybdenum, chromium and vanadium were not produced because of the paucity of data available (at a number of sites, concentrations were below the detection limit).

Conclusions

Surveys were conducted in 1990 and 1991 in the vicinity of the Norton plant to assess the effects of emissions on vegetation. No air pollution injury symptoms were observed on vegetation at any of the survey sites in 1990 or 1991. Traces of surface particulate material were noted on foliage at two sites (4 and 8) in 1990 but none in 1991.

None of the 15 elements examined in 1990 and 1991 foliage exceeded the Phytotoxicology Upper Limit of Normal guidelines. However, slightly elevated concentrations of titanium, copper, molybdenum, chromium, aluminum and vanadium were found in the

1990 and 1991 foliage at sites close to and downwind of the plant. Emissions from Norton may be contributing to these marginally elevated concentrations, however, these values are environmentally inconsequential, except as a possible source-monitoring mechanism.

References

1. **Phytotoxicology Assessment Investigation in the Vicinity of Norton, Niagara Falls - 1990.** Ontario Ministry of the Environment, Air Resources Branch. ARB No. 077-91-Phyto. Toronto, 1991.

TABLE: 1 Observational Notes of Surveillance Foliage Examined in the Vicinity of Norton, Niagara Falls - 1991

Survey Site Number	Distance & Direction from Norton	Vegetation Examined	Observations
1	0.4 km SW	Silver maple	No air pollution injury to foliage with incipient senescence.
2	0.3 km NE	Silver maple	0-1% terminal necrosis on some foliage with incipient senescence (not characteristic of air pollution).
3	0.15 km SE	Silver maple	No air pollution injury symptoms on foliage.
4	0.45 km NE	Silver maple	0-1% terminal necrosis on some foliage with incipient senescence (not characteristic of air pollution).
5	0.7 km NE	Silver maple	No air pollution injury symptoms on foliage.
6	0.3 km SE	Silver maple	2-10% terminal and marginal necrosis on foliage with incipient senescence (not characteristic of air pollution).
7	0.65 km SE	Silver maple	No air pollution injury symptoms on foliage.
8	0.15 km SW	Silver maple	No air pollution injury symptoms on foliage.
9	0.6 km NW	Silver maple	0-1% terminal necrosis on foliage with incipient senescence (not characteristic of air pollution).
10[1]	5.0 km S	Silver maple	No air pollution injury symptoms on foliage with incipient senescence.
11	0.8 km S	Silver maple	No air pollution injury symptoms on foliage with incipient senescence.

[1]Control location.

TABLE: 2 Titanium Concentrations* in Unwashed Silver Mapled Foliage Collected in the Vicinity of Norton, Niagara Falls 1990 & 1991

Survey Site Number	Distance & Direction from Norton	Vegetation Species Sampled	1990	1991
1	0.4 km SW	silver maple	18	15
2	0.3 km SE	silver maple	82	160
3	0.15 km SE	silver maple	38	32
4	0.45 km NE	silver maple	22	17
5	0.7 km NNW	silver maple	15	21
6	0.3 km SW	silver maple	17	33
7	0.65 km SE	silver maple	9	9
8	0.15 km SW	silver maple	60	43
9	0.6 km NW	silver maple	18	33
10**	5.0 km S	silver maple	12	11
11	0.8 km S	silver maple	NR	14
ULN			NG	NG

*ug/g, dry weight, mean of triplicate samples and analysis.
**control location
NR - no results, analysis not conducted.
ULN - Phytotoxicology Upper Limit of Normal Guideline, see appendix.
NG - ULN not established.

TABLE: 3 Sulphur Concentrations* in Unwashed Silver Maple Foliage Collected in the Vicinity of Norton, Niagara Falls 1990 & 1991

Survey Site Number	Distance & Direction from Norton	Vegetation Species Sampled	1990	1991
1	0.4 km SW	silver maple	0.3	0.2
2	0.3 km SE	silver maple	0.2	0.2
3	0.15 km SE	silver maple	0.2	0.1
4	0.45 km NE	silver maple	0.2	0.2
5	0.7 km NNW	silver maple	0.2	0.1
6	0.3 km SW	silver maple	0.2	0.2
7	0.65 km SE	silver maple	0.2	0.1
8	0.15 km SW	silver maple	0.2	0.1
9	0.6 km NW	silver maple	0.2	0.1
10**	5.0 km S	silver maple	0.2	0.1
11	0.8 km S	silver maple	NR	0.2
ULN			0.4%	0.4%

*percent, dry weight, mean of triplicate samples and analysis.
**control location.
NR - no results, analysis not conducted.
ULN - Phytotoxicology Upper Limit of Normal Guideline, see appendix.

TABLE: 4 Copper Concentrations* in Unwashed Silver Mapled Foliage Collected in the Vicinity of Norton, Niagara Falls 1990 & 1991

Survey Site Number	Distance & Direction from Norton	Vegetation Species Sampled	1990	1991
1	0.4 km SW	silver maple	8	5
2	0.3 km SE	silver maple	12	7
3	0.15 km SE	silver maple	6	4
4	0.45 km NE	silver maple	4	4
5	0.7 km NNW	silver maple	7	5
6	0.3 km SW	silver maple	5	5
7.	0.65 km SE	silver maple	5	4
8	0.15 km SW	silver maple	14	11
9	0.6 km NW	silver maple	6	5
10**	5.0 km S	silver maple	12	6
11	0.8 km S	silver maple	NR	6
ULN			20	20

*ug/g, dry weight, mean of triplicate samples and analysis.
**control location
NR - no results, analysis not conducted.
ULN - Phytotoxicology Upper Limit of Normal Guideline, see appendix.

TABLE: 5 Nickel Concentrations* in Unwashed Silver Maple Foliage Collected in the Vicinity of Norton, Niagara Falls 1990 & 1991

Survey Site Number	Distance & Direction from Norton	Vegetation Species Sampled	1990	1991
1	0.4 km SW	Silver maple	<2	<2T
2	0.3 km SE	silver maple	<3	2T
3	0.15 km SE	silver maple	<2	2T
4	0.45 km NE	silver maple	<2	1T
5	0.7 km NNW	silver maple	<0.5	<2T
6	0.3 km SW	silver maple	<0.5	<2T
7	0.65 km SE	silver maple	<0.5	<2T
8	0.15 km SW	silver maple	<1.5	2T
9	0.6 km NW	silver maple	<0.5	<2T
10**	5.0 km S	silver maple	<0.5	2T
11	0.8 km S	silver maple	NR	<2T
ULN			8	8

*ug/g, dry weight, mean of triplicate samples and analysis.
**control location.
T - a measurable trace amount, interpret with caution.
NR - no results, analysis not conducted.
ULN - Phytotoxicology Upper Limit of Normal guideline, see appendix.

TABLE: 6 Zinc Concentrations* in Unwashed Silver Maple Foliage Collected in the Vicinity of Norton, Niagara Falls 1990 & 1991

Survey Site Number	Distance & Direction from Norton	Vegetation Species Sampled	1990	1991
1	0.4 km SW	silver maple	54	60
2	0.3 km SE	silver maple	103	39
3	0.15 km SE	silver maple	47	16
4	0.45 km NE	silver maple	27	25
5	0.7 km NNW	silver maple	41	37
6	0.3 km SW	silver maple	56	30
7	0.65 km SE	silver maple	33	27
8	0.15 km SW	silver maple	48	52
9	0.6 km NW	silver maple	71	53
10**	5.0 km S	silver maple	44	39
11	0.8 km S	silver maple	NR	27
ULN			250	250

*ug/g, dry weight, mean of triplicate samples and analysis.
**Control location.
NR - no results, analysis not conducted.
ULN - Phytotoxicology Upper Limit of Normal guideline, see appendix.

TABLE: 7 Lead Concentrations* in Unwashed Silver Maple Foliage Collected in the Vicinity of Norton, Niagara Falls 1990 & 1991

Survey Site Number	Distance & Direction from Norton	Vegetation Species Sampled	1990	1991
1	0.4 km SW	silver maple	<2	1T
2	0.3 km SE	silver maple	<3	2T
3	0.15 km SE	silver maple	<2	1T
4	0.45 km NE	silver maple	<1	1T
5	0.7 km NNW	silver maple	<2	1T
6	0.3 km SW	silver maple	<2	1T
7	0.65 km SE	silver maple	<1	1T
8	0.15 km SW	silver maple	<3	2T
9	0.6 km NW	silver maple	<2	1T
10**	5.0 km S	silver maple	<2	DL
11	0.8 km S	silver maple	NR	1T
ULN			60	60

*ug/g, dry weight, mean of triplicate samples and analysis.
**control location.
T - a measurable trace amount, interpret with caution.
NR - no results, analysis not conducted.
DL - at or below analytical detection limit.
ULN - Phytotoxicology Upper Limit of Normal guideline, see appendix.

TABLE: 8 Cadmium Concentrations* in Unwashed Silver Maple Foliage Collected in the Vicinity of Norton, Niagara Falls 1990 & 1991

Survey Site Number	Distance & Direction from Norton	Vegetation Species Sampled	1990	1991
1	0.4 km SW	silver maple	<0.1	0.2T
2	0.3 km SE	silver maple	<0.2	0.1T
3	0.15 km SE	silver maple	<0.1	DL
4	0.45 km NE	silver maple	<0.1	0.2T
5	0.7 km NNW	silver maple	<0.1	DL
6	0.3 km SW	silver maple	<0.1	0.1T
7	0.65 km SE	silver maple	<0.1	DL
8	0.15 km SW	silver maple	<0.1	DL
9	0.6 km NW	silver maple	<0.2	0.1T
10**	5.0 km S	silver maple	<0.2	0.2T
11	0.8 km S	silver maple	NR	0.1T
ULN			2	2

*ug/g, dry weight, mean of triplicate samples and analysis.
**control location.
T - a measurable trace amount, interpret with caution.
NR - no results, analysis not conducted.
DL - at or below analytical detection limit.
ULN - Phytotoxicology Upper Limit of Normal guideline, see appendix.

TABLE: 9 Sodium Concentrations* in Unwashed Silver Maple Foliage Collected in the Vicinity of Norton, Niagara Falls 1990 & 1991

Survey Site Number	Distance & Direction from Norton	Vegetation Species Sampled	1990	1991
1	0.4 km SW	silver maple	17	14
2	0.3 km SE	silver maple	38	49
3	0.15 km SE	silver maple	22	24
4	0.45 km NE	silver maple	33	25
5	0.7 km NNW	silver maple	20	31
6	0.3 km SW	silver maple	41	160
7	0.65 km SE	silver maple	19	37
8	0.15 km SW	silver maple	62	32
9	0.6 km NW	silver maple	28	31
10**	5.0 km S	silver maple	22	22
11	0.8 km S	silver maple	NR	16
ULN			350	350

*ug/g, dry weight, mean of triplicate samples and analysis.
**control location.
NR - no results, analysis not conducted.
ULN - Phytotoxicology Upper Limit of Normal guideline, see appendix.

TABLE: 10 Cobalt Concentrations* in Unwashed Silver Maple Foliage Collected in the Vicinity of Norton, Niagara Falls 1990 & 1991

Survey Site Number	Distance & Direction from Norton	Vegetation Species Sampled	1990	1991
1	0.4 km SW	silver maple	<0.2	DL
2	0.3 km SE	silver maple	<0.2	0.5T
3	0.15 km SE	silver maple	<0.4	DL
4	0.45 km NE	silver maple	<0.2	0.3T
5	0.7 km NNW	silver maple	<0.2	0.3T
6	0.3 km SW	silver maple	<0.4	DL
7	0.65 km SE	silver maple	<0.2	DL
8	0.15 km SW	silver maple	<0.3	0.3T
9	0.6 km NW	silver maple	<0.3	DL
10**	5.0 km S	silver maple	<0.2	DL
11	0.8 km S	silver maple	NR	DL
ULN			2	2

*ug/g, dry weight, mean of triplicate samples and analysis.
**control location.
T - a measurable trace amount, interpret with caution.
NR - no results, analysis not conducted.
DL - at or below analytical detection limit.
ULN - Phytotoxicology Upper Limit of Normal guideline, see appendix.

TABLE: 11 Molybdenum Concentrations* in Unwashed Silver Maple Foliage Collected in the Vicinity of Norton, Niagara Falls 1990 & 1991

Survey Site Number	Distance & Direction from Norton	Vegetation Species Sampled	1990	1991
1	0.4 km SW	silver maple	<0.3	0.2T
2	0.3 km SE	silver maple	<0.8	1.3
3	0.15 km SE	silver maple	<0.2	0.5T
4	0.45 km NE	silver maple	<0.3	0.4T
5	0.7 km NNW	silver maple	<0.3	0.3T
6	0.3 km SW	silver maple	<1.0	DL
7	0.65 km SE	silver maple	<0.5	0.2T
8	0.15 km SW	silver maple	<0.4	0.8T
9	0.6 km NW	silver maple	<0.2	DL
10**	5.0 km S	silver maple	<0.4	DL
11	0.8 km S	silver maple	NR	DL
ULN			1.5	1.5

*ug/g, dry weight, mean of triplicate samples and analysis.
**control location.
T - a measurable trace amount, interpret with caution.
NR - no results, analysis not conducted.
DL - at or below analytical detection limit.
ULN - Phytotoxicology Upper Limit of Normal guideline, see appendix.

TABLE: 12 Manganese Concentrations* in Unwashed Silver Maple Foliage Collected in the Vicinity of Norton, Niagara Falls 1990 & 1991

Survey Site Number	Distance & Direction from Norton	Vegetation Species Sampled	1990	1991
1	0.4 km SW	silver maple	53	55
2	0.3 km SE	silver maple	220	32
3	0.15 km SE	silver maple	93	43
4	0.45 km NE	silver maple	47	19
5	0.7 km NNW	silver maple	21	22
6	0.3 km SW	silver maple	40	22
7	0.65 km SE	silver maple	45	24
8	0.15 km SW	silver maple	36	33
9	0.6 km NW	silver maple	160	173
10**	5.0 km S	silver maple	180	180
11	0.8 km S	silver maple	NR	46
ULN			NG	NG

*ug/g, dry weight, mean of triplicate samples and analysis.
**control location.
NR - no results, analysis not conducted.
ULN - Phytotoxicology Upper Limit of Normal guideline, see appendix.
NG - ULN not established.

TABLE: 13 Chromium Concentrations* in Unwashed Silver Maple Foliage Collected in the Vicinity of Norton, Niagara Falls 1990 & 1991

Survey Site Number	Distance & Direction from Norton	Vegetation Species Sampled	1990	1991
1	0.4 km SW	silver maple	<0.5	0.7T
2	0.3 km SE	silver maple	<0.7	2.4T
3	0.15 km SE	silver maple	<0.5	1.1T
4	0.45 km NE	silver maple	<0.5	0.7T
5	0.7 km NNW	silver maple	<0.5	0.6T
6	0.3 km SW	silver maple	<0.5	1.3T
7	0.65 km SE	silver maple	<0.5	DL
8	0.15 km SW	silver maple	<1.5	2.6T
9	0.6 km NW	silver maple	<0.5	1.4T
10**	5.0 km S	silver maple	<0.5	0.9T
11	0.8 km S	silver maple	NR	0.7T
ULN			8	8

*ug/g, dry weight, mean of triplicate samples and analysis.
**control location.
T - a measurable trace amount, interpret with caution.
DL - at or below analytical detection limit.
NR - no results, analysis not conducted.
ULN - Phytotoxicology Upper Limit of Normal guideline, see appendix.

TABLE: 14 Aluminum Concentrations* in Unwashed Silver Maple Foliage Collected in the Vicinity of Norton, Niagara Falls 1990 & 1991

Survey Site Number	Distance & Direction from Norton	Vegetation Species Sampled	1990	1991
1	0.4 km SW	silver maple	81	82
2	0.3 km SE	silver maple	293	300
3	0.15 km SE	silver maple	203	180
4	0.45 km NE	silver maple	122	84
5	0.7 km NNW	silver maple	82	112
6	0.3 km SW	silver maple	81	153
7	0.65 km SE	silver maple	63	66
8	0.15 km SW	silver maple	463	400
9	0.6 km NW	silver maple	73	240
10**	5.0 km S	silver maple	96	90
11	0.8 km S	silver maple	NR	82
ULN			500	500

*ug/g, dry weight, mean of triplicate samples and analysis.
**control location.
NR - no results, analysis not conducted.
ULN - Phytotoxicology Upper Limit of Normal guideline, see appendix.

TABLE: 15 Strontium Concentrations* in Unwashed Silver Maple Foliage Collected in the Vicinity of Norton, Niagara Falls 1990 & 1991

Survey Site Number	Distance & Direction from Norton	Vegetation Species Sampled	1990	1991
1	0.4 km SW	silver maple	28	25
2	0.3 km SE	silver maple	45	27
3	0.15 km SE	silver maple	34	30
4	0.45 km NE	silver maple	30	19
5	0.7 km NNW	silver maple	23	25
6	0.3 km SW	silver maple	49	52
7	0.65 km SE	silver maple	27	29
8	0.15 km SW	silver maple	20	20
9	0.6 km NW	silver maple	30	35
10**	5.0 km S	silver maple	63	51
11	0.8 km S	silver maple	NR	30
ULN			NG	NG

*ug/g, dry weight, mean of triplicate samples and analysis.
**control location.
NR - no results, analysis not conducted.
ULN - Phytotoxicology Upper Limit of Normal guideline, see appendix.
NG - ULN not established.

TABLE: 16 Vanadium Concentrations* in Unwashed Silver Maple Foliage Collected in the Vicinity of Norton, Niagara Falls 1990 & 1991

Survey Site Number	Distance & Direction from Norton	Vegetation Species Sampled	1990	1991
1	0.4 km SW	silver maple	<1	0.5T
2	0.3 km SE	silver maple	<3	3.8T
3	0.15 km SE	silver maple	<2	1T
4	0.45 km NE	silver maple	<1	0.7T
5	0.7 km NNW	silver maple	<1	0.8T
6	0.3 km SW	silver maple	<1	1T
7	0.65 km SE	silver maple	<1	DL
8	0.15 km SW	silver maple	<3	2.7T
9	0.6 km NW	silver maple	<1	1T
10**	5.0 km S	silver maple	<1	DL
11	0.8 km S	silver maple	NR	0.5T
ULN			5	5

*ug/g, dry weight, mean of triplicate samples and analysis.
**control location.
T - a measurable trace amount, interpret with caution.
NR - no results, analysis not conducted.
DL - at or below analytical detection limit.
ULN - Phytotoxicology Upper Limit of Normal guideline, see appendix.

FIGURE: 1 Phytotoxicology Vegetation Survey Sites
in the Vicinity of Norton, Niagara Falls - 1991

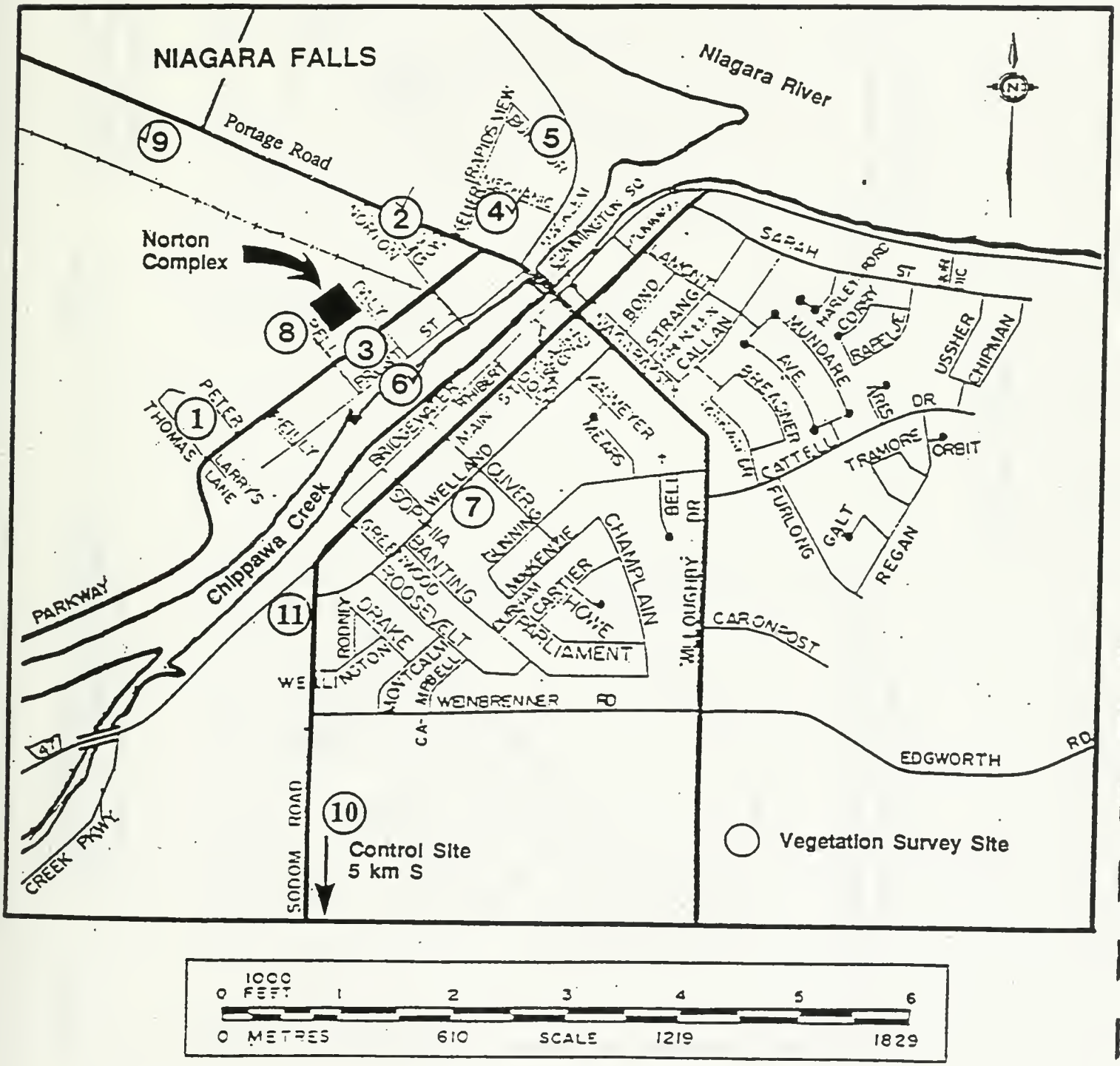
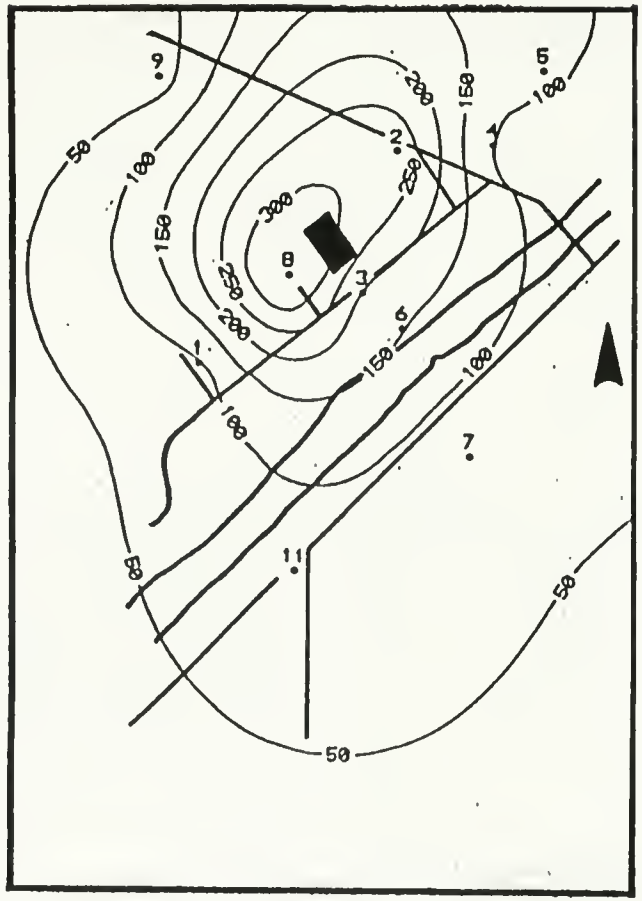
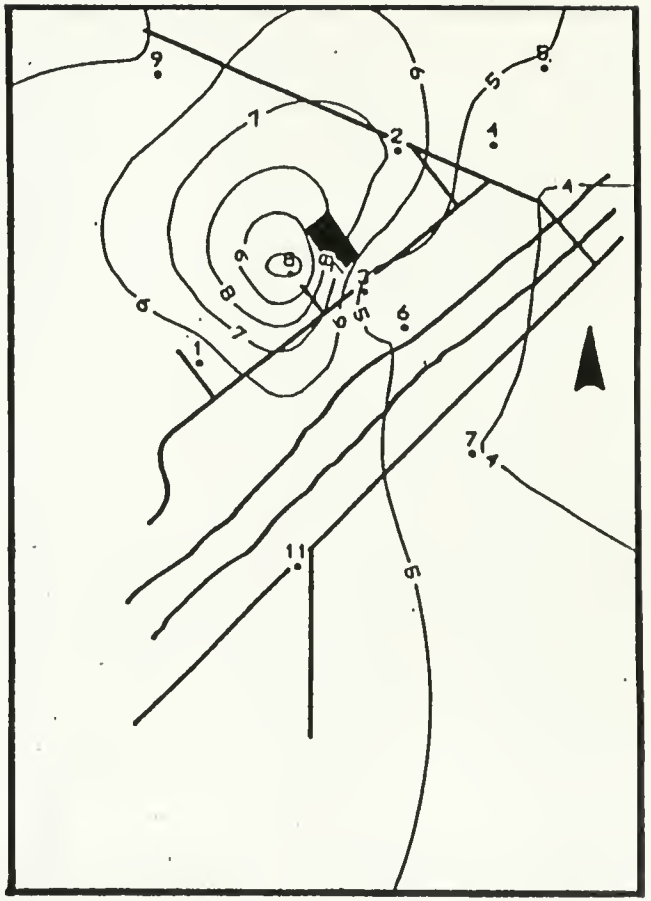


FIGURE: 2 Contour Map Showing Distribution of Aluminum in Foliage in the Vicinity of Norton, Niagara Falls, 1991.



Contour interval - 50 ppm

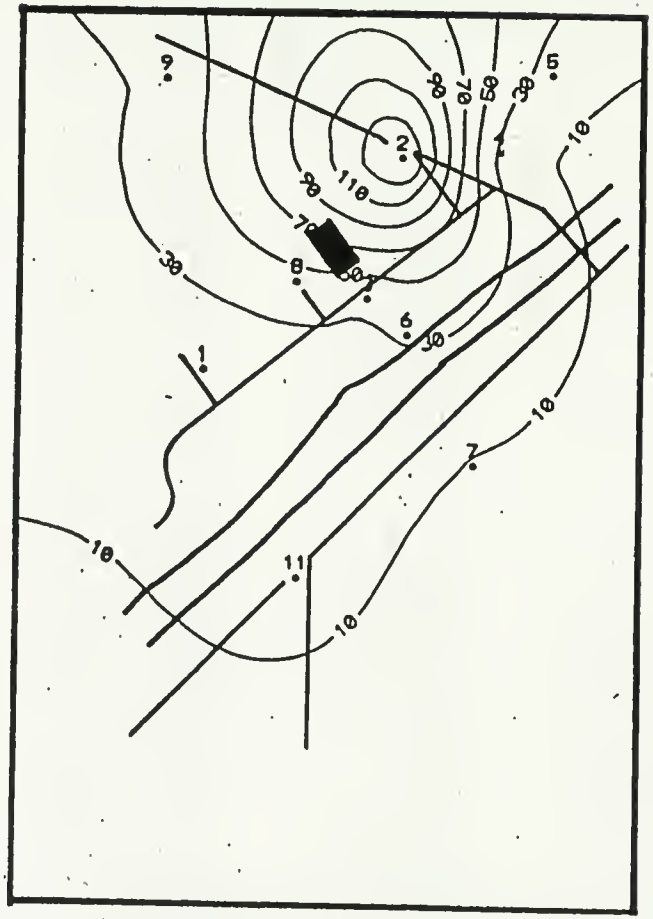
FIGURE: 3 Contour Map Showing Distribution of Copper in Foliage in the Vicinity of Norton, Niagara Falls, 1991.



Contour interval - 1 ppm

No Scale Provided

FIGURE: 4 Contour Map Showing Distribution of Titanium in Foliage in the Vicinity of Norton, Niagara Falls, 1991.



Contour interval - 20 ppm

No Scale Provided

Derivation and Significance of the MOEE Phytotoxicology
"Upper Limits of Normal" Contaminant Guidelines.

The MOEE Upper Limits of Normal (ULN) contaminant guidelines represent the expected maximum concentration in surface soil, foliage (trees and shrubs), grass, moss bags, and snow from areas in Ontario not exposed to the influence of a pollution source. Urban ULN guidelines are based on samples collected from urban centres, whereas rural ULN guidelines were developed from non-urbanized areas. Samples were collected by Phytotoxicology staff using standard sampling procedures (reference: *Ontario Ministry of the Environment. 1989. Ontario Ministry of the Environment "Upper Limit of Normal" Contaminant Guidelines for Phytotoxicology Samples. Phytotoxicology Section, Air Resources Branch: Technical Support Sections NE and NW Regions, Report No. ARB-138-88-Phyto. ISBN: 0-7729-5143-8.*). Chemical analyses were conducted by the MOEE Laboratory Services Branch.

The ULN is the arithmetic mean plus three standard deviations of the suitable background data for each chemical element and parameter. This represents 99% of the sample population. This means that for every 100 samples that have not been exposed to a pollution source, 99 will fall within the ULN.

The ULNs do not represent maximum desirable or allowable limits. Rather, they are an indication that concentrations that exceed the ULN may be the result of contamination from a pollution source. Concentrations that exceed the ULNs are not necessarily toxic to plants, animals, or people. Concentrations that are below the ULNs are not known to be toxic.

ULNs are not available for all elements. This is because some elements have a very large range in the natural environment and the ULN, calculated as the mean plus three standard deviations, would be unrealistically high. Also, for some elements, insufficient background data is available to confidently calculate ULNs. The MOEE Phytotoxicology ULNs are constantly being reviewed as the background environmental data base is expanded. This will result in more ULNs being established and may amend existing ULNs.